SEP 11 1981

EXISTING CORRIDOR

NATURAL ENVIRONMENT

HAMILTON-WENTWORTH RAPID TRANSIT PROJECT

Prepared By: Marshall, Macklin, Monaghan /Hatch Associates Ltd.

For Submission By: Metro Canada Limited

To: The Regional Municipality of Hamilton-Wentworth

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MCL Report HW-1-6.0
Part of Task 4.4
March 13, 1981

004754

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March 13, 1981

Mr. M.M. Ross
Project Co-Ordinator
Rapid Transit Project
100 Main Street East
Hamilton, Ontario
L8N 3V9

Dear Mr. Ross:

Subject: Report HW-1-6.0
Existing Corridor Natural Environment

We are pleased to submit final report HW-1-6.0, Existing Corridor Natural Environment. This report is submitted in accordance with the requirements described in Task 4.4 (Sub-section 4.4 of Schedule A to the UTDC - Region Pre-implementation Program Contract). This report has been prepared under Metro Canada direction by Marshall, Macklin, Monaghan/Hatch Associates Ltd., and has previously been reviewed in draft form by the Technical Advisory Committee. We trust that the few comments that the Committee did have are satisfactorily reflected in this final report.

We have enclosed with this letter one bound copy for your use, and one unbound copy suitable for reproduction.

Very truly yours,

P.J. McCann
Project Manager

PJM:jp

Encl.

cc: C.T.C. Armstrong

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1.0 INTRODUCTION

This document provides an overview of the natural environment within the Study Corridor. Within this context, the natural environment is understood to encompass the following biophysical characteristics: geology; physiography; topography; soils; hydrology; water quality; air quality; climate; vegetation; wildlife; and environmentally sensitive or significant areas; in compliance with The Environmental Assessment Act 1975 (Appendix A).

2.0 STUDY SCOPE

This study has been based primarily on secondary data sources prepared by government agencies at the local, regional and provincial levels, and augmented by selective field investigation and airphoto interpretation. Descriptions of the natural environment are qualitative in nature and pertain to the Study Corridor. Future studies will address specific alignments and be quantitative in their approach.

The purpose of this report is to define, in a general fashion, those biophysical characteristics of the study area that may pose a constraint to the proposed undertaking. Thus, in addition to documenting the natural environment of the Study Corridor, this report examines potential opportunities and constraints, as well as the potential impacts associated with the proposed undertaking, to the full extent allowed by the current data base.

3.0 THE NATURAL ENVIRONMENT

3.1 Geology

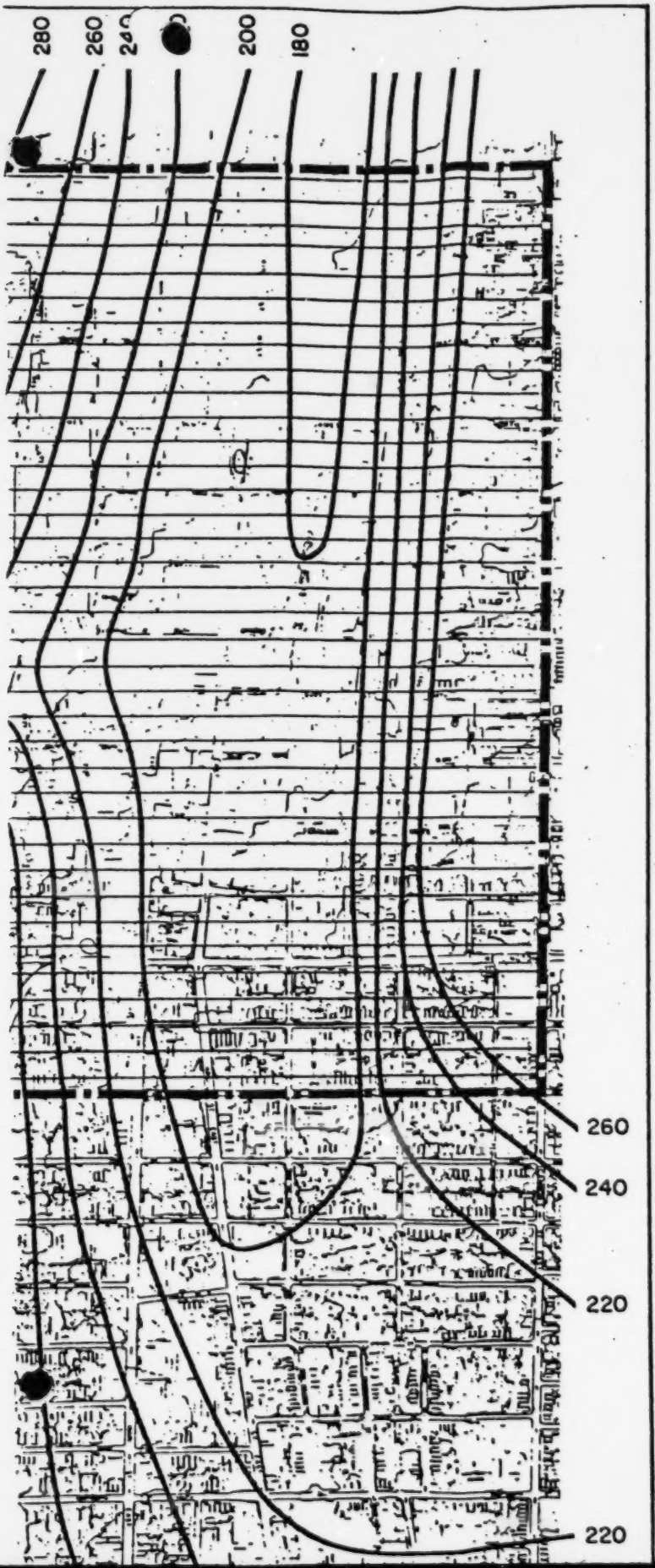
The Study Corridor, like most of eastern Canada, rests on a basement of crystalline Precambrian bedrock.

About 550 million years ago, the Great Lakes Basin was inundated by a large inland sea. Sediments washed into this sea from the surrounding highlands eventually consolidated to form thick interbedded layers of sandstone, shale, siltstone and mudstone. At the same time, the profuse skeletal remains of corals and other marine species consolidated to form limestones.

About 250 million years ago, the area was subject to the first of two major uplifts of cataclysmic proportion. During this first event, the newly formed sedimentary rocks were raised differentially above sea level, while at the same time, developing a tilt slightly downward to the southwest. With time and exposure to the elements, a distinctive drainage pattern developed, and over the next 100 million years the resulting landscape was eroded to form a relatively flat, almost featureless plain.

Following a second uplift of the area, some 150 million years ago, the land developed a slight tilt northward, thus initiating a new system of drainage patterns caused by renewed erosional activity. The development of the Niagara Escarpment is thought to have started soon thereafter, as the exposed shales on its western flank underwent preferential erosion from precipitation and surface runoff. Later, repeated glacial advances and extended periods of interglacial erosion significantly altered the Escarpment and all other land features to their present forms.

Bedrock of the Study Corridor consists of thick, gently tilting beds of Paleozoic sedimentary rock of Ordovician and Silurian age, approximately 610 meters (2,000 feet) thick (Drawing 1). This complex tilts downward to the south and west at a slope of about 0.4 to 0.6 percent.



BEDROCK GEOLOGY

(After Golder, 1976)

Legend

LOCKPORT FORMATION
- Eramosa

LOCKPORT FORMATION
- Gasport
- Goat Island
- Unnamed

CATARACT AND CLINTON GROUPS (ESCARPMENT)

QUEENSTON FORMATION

—260— CONTOURS OF TOP BEDROCK

APPROXIMATE BEDROCK BOUNDARIES

N

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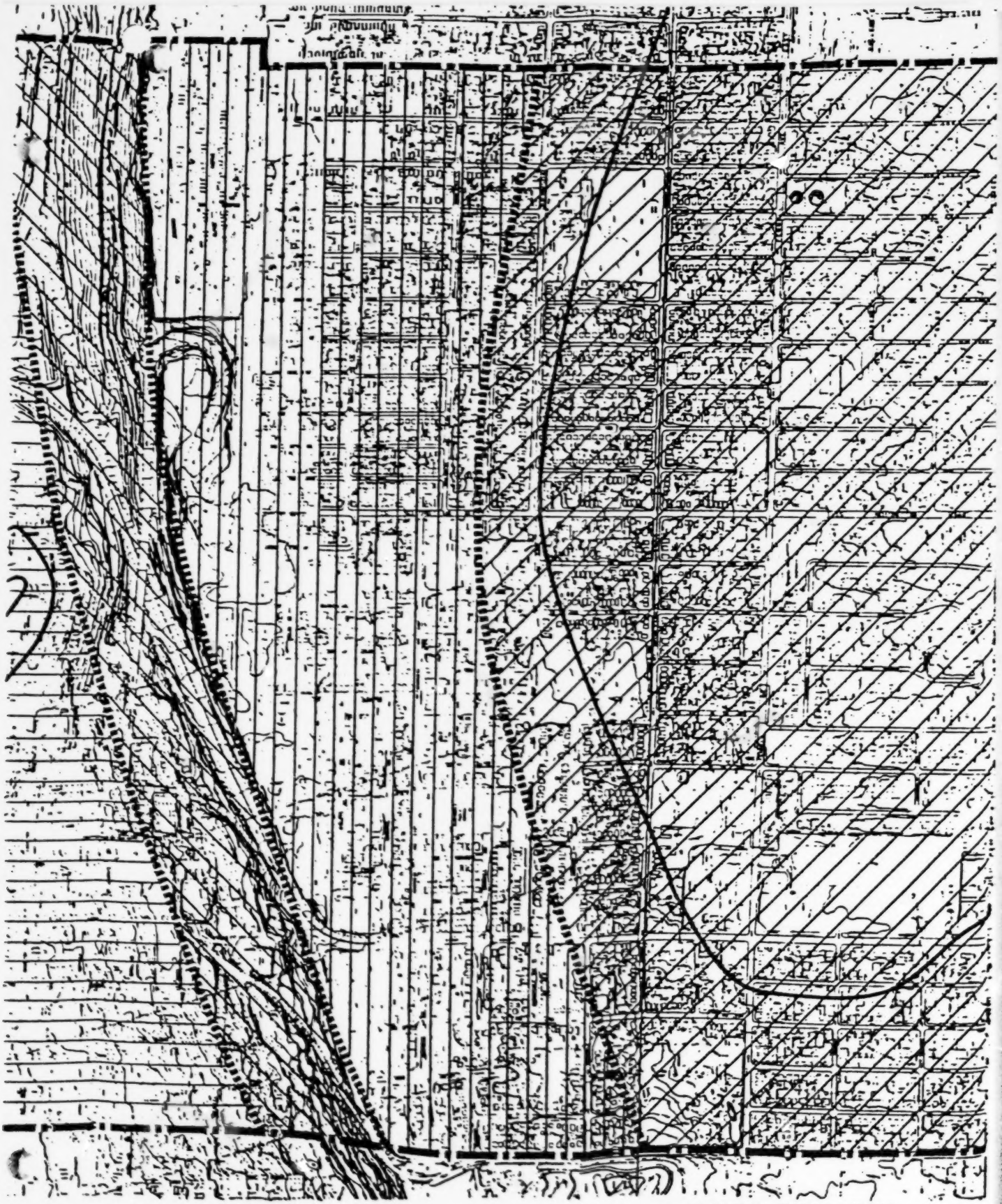
Drawing No.1

Marshall Macklin Monaghan Limited



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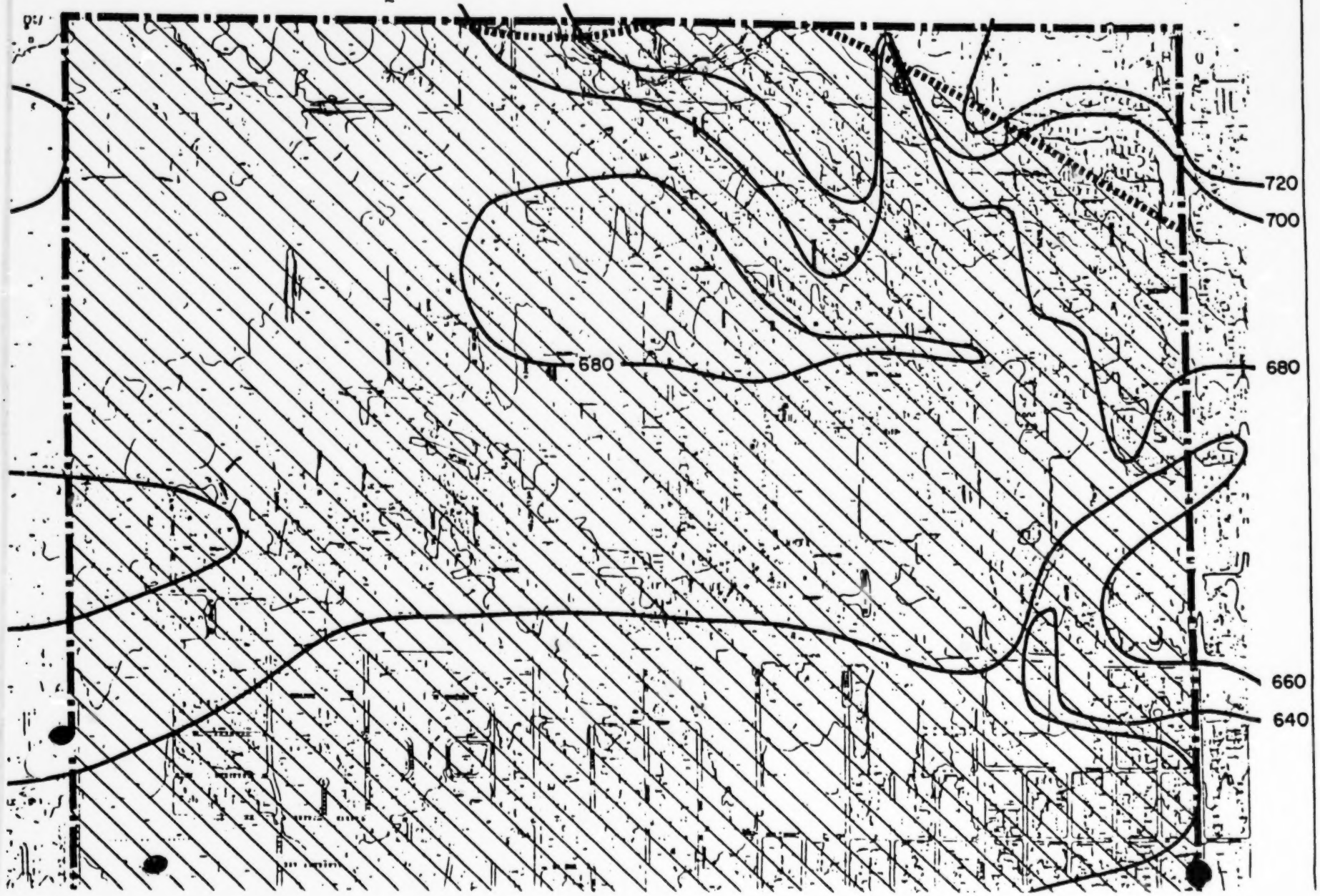

720
700
680
660
640

Below the Escarpment, bedrock consists of shales of the Queenston formation. These rocks are essentially red mudstones with small inclusions of green siltstone. Buried, for the most part, by overburden, these shales are highly weathered, weak and erodible.

On top of the Escarpment are the youngest rocks in the series, consisting of dolomites and limestones of the Guelph and Lockport formations. While some of these rocks are generally sound, and in some cases porous, others are fractured.

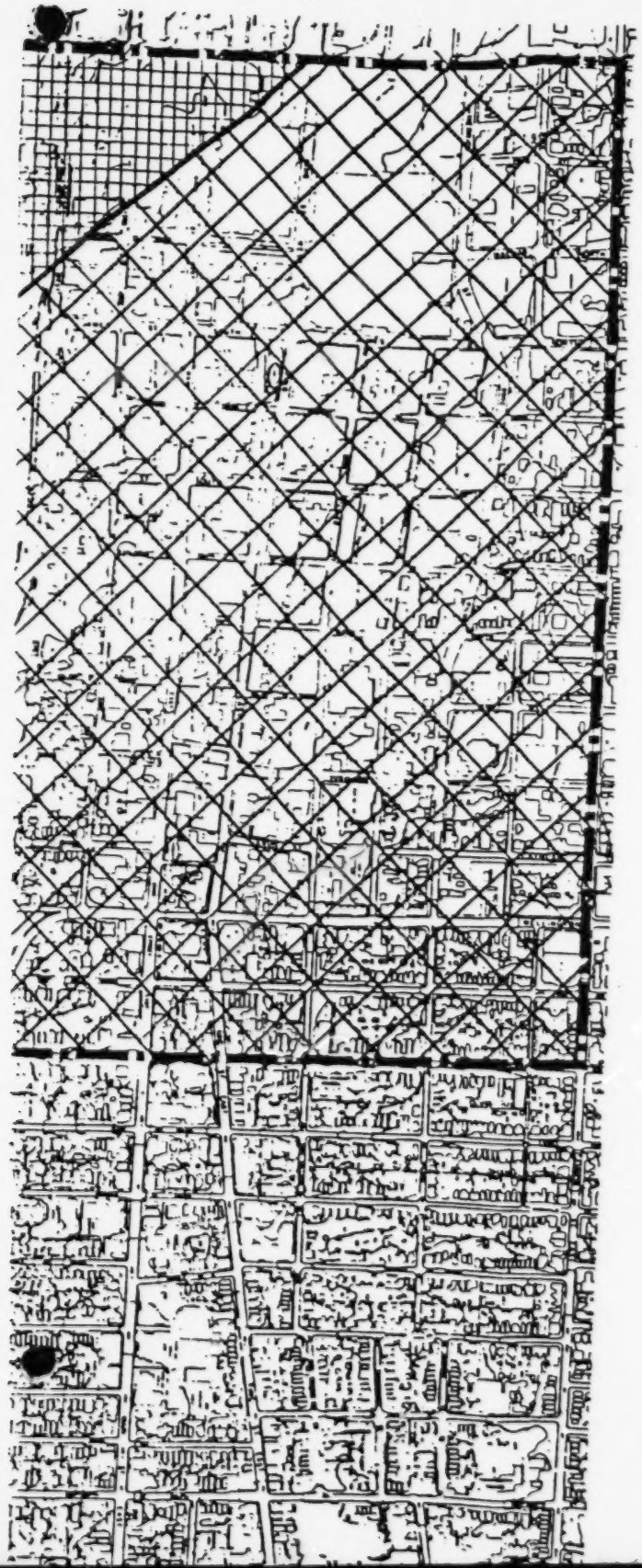
Exposed on the Niagara Escarpment is a bedrock sequence whose geological age lies between that of the Queenston and Eramosa formations and includes the Clinton Group. Below this sequence is the Cataract Group, consisting of shales, limestones, dolomites and sandstone. The shales of the Cataract series reach considerable thickness and owing to their susceptibility to preferential weathering, are the major cause of Escarpment regression.

3.2 Physiography and Soils

The Study Corridor consists of portions of three major physiographic regions: the Iroquois Lake Plain, the Niagara Escarpment and the Haldimand Clay Plain. (Drawing 2).

a) The Iroquois Lake Plain

The Iroquois Lake Plain is bounded to the north by Hamilton Harbour, and to the south by the base of the Escarpment. Regionally, the Plain forms part of an ancient lake basin which extends completely around the present-day shoreline of Lake Ontario to a distance of approximately three kilometres (two miles) inland. The soils typically consist of gently undulating, stratified, fine silty sands overlying lacustrine clays, silts and clay tills. Associated with this complex are a major sand beach bar which extends under Westdale and West Hamilton and remnants of an abandoned shoreline situated in the area immediately below the Escarpment. Portions of both Hamilton and Burlington are located on the Iroquois Plain.



LANDFORMS

(After Chapman and Putnam, 1967)

Legend

- CLAY PLAINS
- TILL MORAINE (HALTON TILL)
- ESCARPMENT
- BEACHES AND SHORECLIFFS
- SAND PLAINS

N

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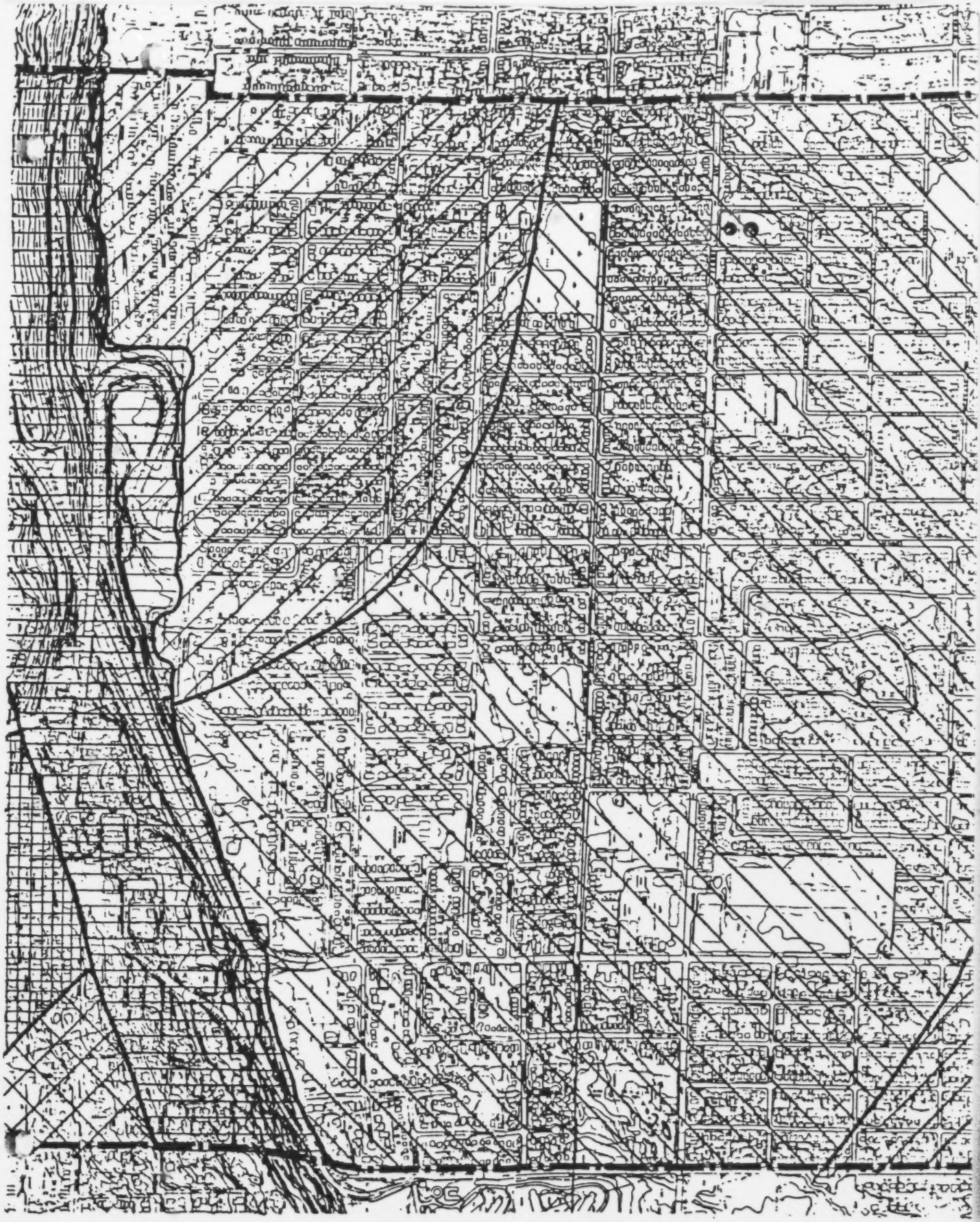
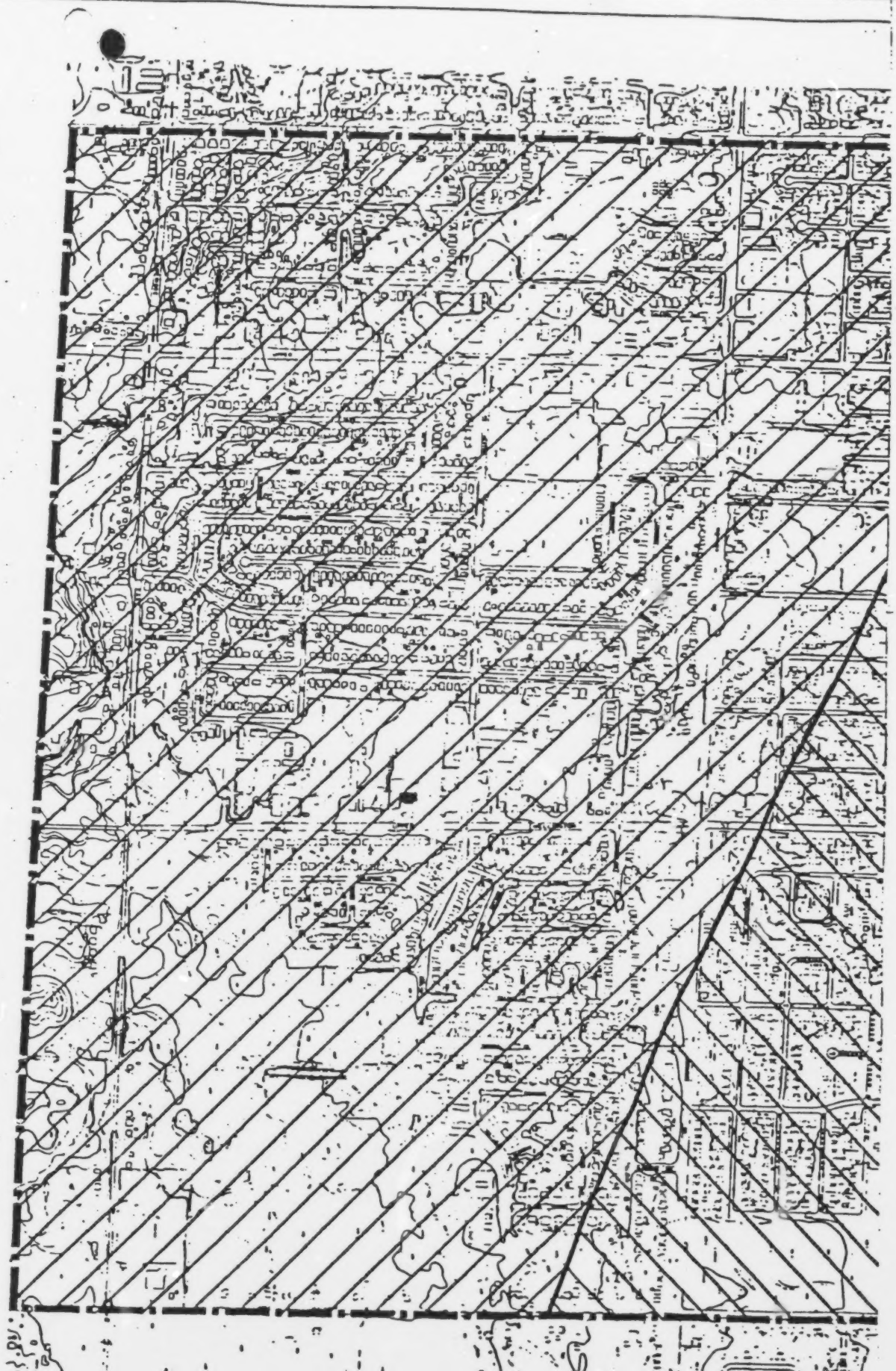
Drawing No.2





b) Niagara Escarpment

The Niagara Escarpment consists of hard dolomites, limestones and sandstones interbedded with softer, more erodible shales (See Figure 1). Greater susceptibility to weathering because of ground water seepage, precipitation, surface runoff and frost action, has caused the shales to erode at a comparatively faster rate than the other rocks which make up the formation. As a result of continuous regression of the shales, the superimposed bedrock is subject to undermining which contributes to the formation of precarious overhangs and cornices. Further recession of the shale beds initiates the mass-wasting of large blocks of dolomite and limestone, accumulations of which form as rock debris (talus), and slope wash (colluvium) at the base of the Escarpment. In the Study Corridor, this talus commonly consists of large angular blocks of limestone, dolomite and to a lesser extent, sandstone, set in a matrix of clay, silt and sand derived from the weathered shales and sandstones.

Generally, this talus material is unstable and poses a number of special engineering problems to construction. The fissured and fractured nature of the uppermost layers of bedrock is similarly expected to pose special problems to the design of foundations and other construction activities.

c) Haldimand Clay Plain

The Haldimand Clay Plain is confined to the area on top of the Escarpment. Soils consist of a relatively shallow sequence of lacustrine clays overlying glacial tills. Occasionally, however, these buried tills rise to the surface in the form of low morainic ridges. (See Drawing 3)

Although shallow over much of the upper plateau, the soils tend to be deeper in the southern portion, averaging less than 15 meters (50 feet) in depth. Nearer the Escarpment, soils in places are less than one metre (three feet) in depth.

Soils of the Haldimand Clay Plain typically support heavy agricultural use. The Canada Land Inventory (ARDA) categorizes this land as having a capability of Class 1 (60 percent) and Class 3 (40%) for agriculture. Where they exist, agricultural restrictions result from the poor drainage properties of the clay soils and from deficiencies in lime, phosphorus and organic matter.

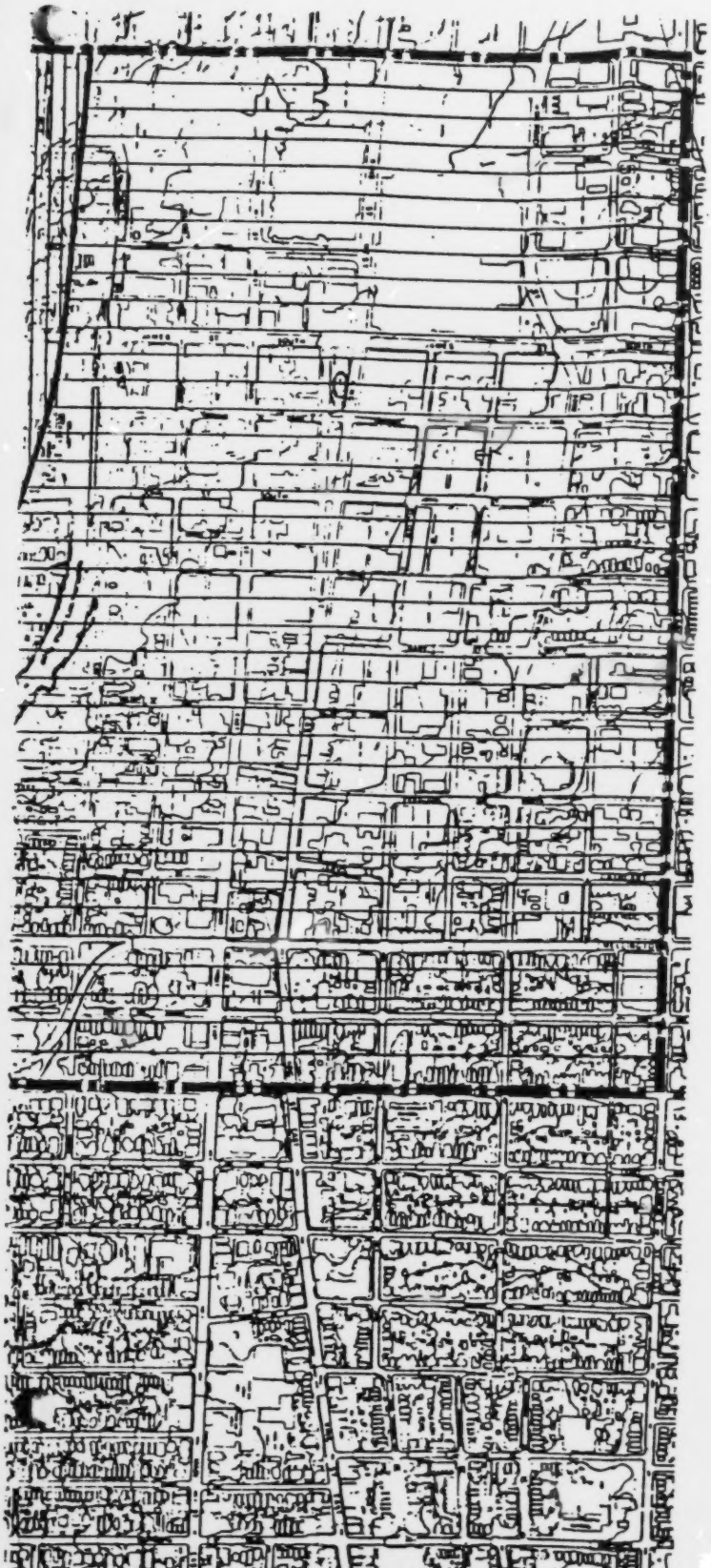
3.3 Hydrology

a) Surface Water

In the context of this report, surface water is considered as any water that stands or runs at, or near the ground surface. The primary sources of surface water in the Hamilton Wentworth area are:

i) precipitation (which averages approximately 118 millimetres [30 inches] per year);
ii) groundwater passing through the region, eventually to emerge as springs or seepage zones at the surface; and
iii) transient surface water such as streams.

While most of the surface water in the study area is destined to drain into Lake Ontario via local storm sewers, or some natural drainage systems, some of it seeps into the ground to recharge local aquifers, while a still smaller percentage is lost to the atmosphere through evapotranspiration. As surface drainage is extensively controlled by municipal services in the corridor, the impact of the proposed undertaking on water quality is expected to be minimal. This aspect must be examined in more detail, however, on a site specific basis.



SURFICIAL SOIL S

(After Trow, 1980)

Legend

- LACUSTRINE SANDS, SILT AND SAND AND GRAVEL DEPOSITS
- SILTY CLAY OR CLAYEY SILT TILL
- LACUSTRINE SILTY CLAY CLAYEY SILT
- ESCARPMENT ZONE (TALUS DEPOSITS)
- SOIL BOUNDARY

N

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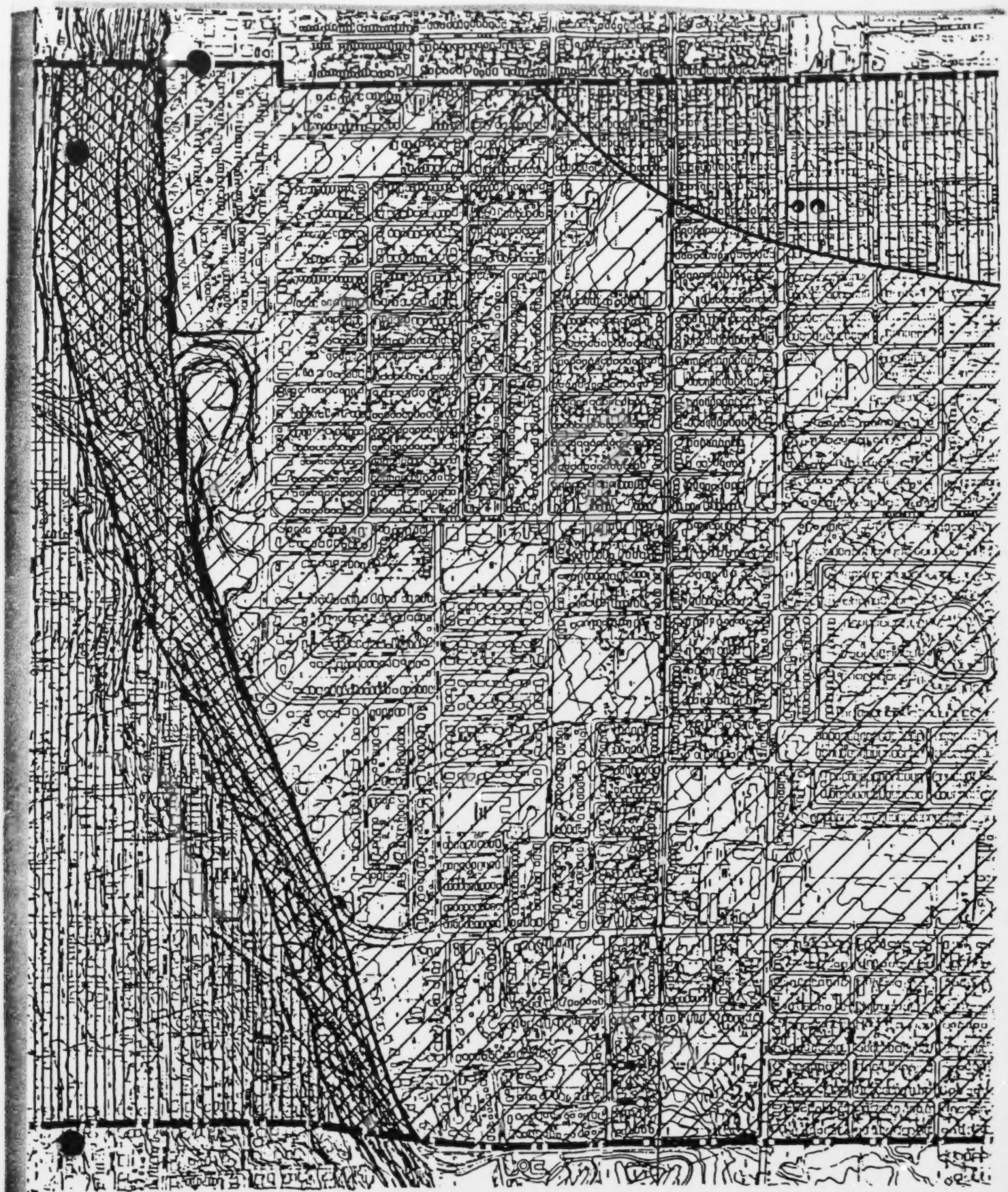
Drawing No. 3



b) Groundwater

Within this largely urbanized study area, groundwater hydrology is strongly influenced by development, specifically storm drainage facilities. Primarily because of these drainage facilities, surface water infiltration appears limited. Consequently, the area's capacity to contribute recharge to the regional aquifer also appears limited. The regional aquifer, in this case, consists of a relatively shallow groundwater system which either follows the fissures and fractures in the underlying Paleozoic bedrock, or enters the aquifer through the overburden immediately above the bedrock. Through springs and seepage zones, some of this water is lost to the Niagara Escarpment and eventually to Lake Ontario, while some is intercepted by the buried valleys now entrenched in the Escarpment. This aspect requires further study with respect to the impact of the proposed undertaking on groundwater quality.

Records indicate the presence of a limited number of hydrologically productive overburden aquifers, particularly in the Study Corridor and its environs. In general, groundwater flow is somewhat restricted in the soil owing to the preponderance of silt and clay contained in the glaciolacustrine and glacial till overburden. As a result, most operative wells in the region rely on bedrock aquifers for potable water supplies. Of course, the provision of full municipal services, throughout most of the Study Corridor, all but eliminates the need for private well points, except for very specialized purposes. However, this study did not find any such wells in operation within the Corridor.

On a regional scale, the highest well yields are reported above the Escarpment where the Lockport and Amabel dolomites transmit comparatively larger quantities of groundwater than does the till overburden. However, much of the groundwater reaching the Escarpment is lost as seepage at the contact between the Silurian dolomite and the older Ordovican Queenston shales. In contrast, the Queenston shales below the Escarpment are generally less

c) Infiltration Zones

Infiltration zones are defined as areas of potential recharge whose native soils are sufficiently permeable to allow the percolation of surface water to the groundwater regime. On a regional scale, such zones not only play an important role in helping to replenish groundwater reserves, but also help to maintain baseflows in streams and rivers.

Within the study corridor, no significant infiltration zones were identified, although some of the permeable sand and gravel beach deposits below the escarpment and the fractured Lockport and Amabel dolomite formations situated above the face of the Escarpment could have some minor local significance in this regard.

d) Shallow Water Bearing Zones

Shallow water bearing zones are anticipated to extend close enough to the ground surface, both above and below the Escarpment, so as to interfere with construction activity. This condition is expected to be particularly significant in the vicinity of the Escarpment as evidenced by the presence of numerous water seepage zones near the base.

Specific mitigative measures should, therefore, be considered in order not to seal outlets of aquifers which drain from the escarpment. Consequently, related engineering constraints are expected to vary depending on location.

While most high water table conditions are controllable during construction, usually by means of pumping or well pointing; they tend to hinder construction to some extent. Often, local drainage characteristics are either temporarily or irreparably altered.

Typically, zones of high water table occur in areas of poorly drained soils, exposed bedrock, or in areas with shallow overburden overlying massive bedrock formations.

In the absence of detailed site-specific information, no significant areas of high water table have been identified within the corridor. This is largely as a result of the influence of storm sewer facilities.

3.4 Topography

The Niagara Escarpment divides the study corridor roughly into two major sections, an upper plateau and a lower plateau. The change in elevation between these two features is approximately 100 metres.

The topography, both above and below the Escarpment, is generally flat, with slopes averaging less than 5% (Drawing No. 4). At the Escarpment, however, slopes often exceed 70% slope.

The precipitous slopes associated with the Escarpment may pose special construction constraints.

3.5 Water Quality

No natural water courses exist within the Study Corridor, as runoff generally drains to underground storm sewers. The overall environmental impact of the project on ground and surface water quality will be examined further in subsequent studies.

3.6 Vegetation

a) Regional Context

The Study Corridor lies within the Niagara Escarpment section of the Deciduous Forest Region (Rowe, 1972). Also referred to as the Carolinean Region, this zone, although relatively extensive in the United States, is restricted in Canada primarily to southwestern Ontario and the northern fringe of Lake Ontario.

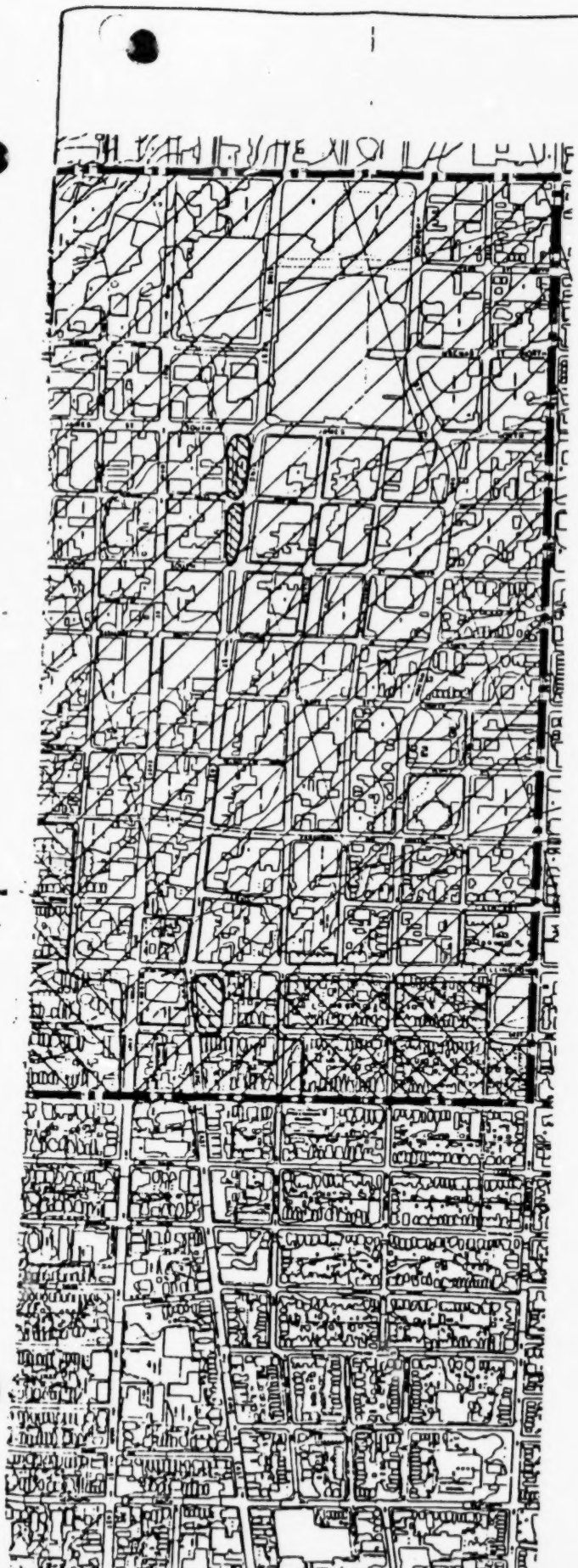
The significance of this forest region is that it occupies the smallest geographical area of any forest region in Canada and is the main source of such valuable species as black walnut, swamp white oak and shagbark hickory. More widely distributed hardwood species such as butternut and bitternut hickory, rock elm, silver maple and blue beech also occur in association with a more scattered distribution of tulip trees, sassafras, blue ash, black gum, pawpaw and Kentucky coffee tree.

The significance of the remaining Carolinean species in southern Ontario increases because of extensive clearing programs carried out in the past for agricultural purposes. For example, forest cover ranges from a maximum of 10% of land area in such areas as Oxford County to three to four percent in Essex County (Marshall Macklin Monaghan, 1977). Further, the ongoing displacement of many of the Carolinean species by more competitive species of the Great Lakes - St. Lawrence Forest Region makes protection of remaining stands of the Carolinean or Deciduous Forest Region extremely important if, in terms of indigenous tree cover, it is to be retained.

b) Vegetation Within the Study Corridor

Much of the tree cover in the Study Corridor has been removed as a result of the constantly expanding urbanization of Hamilton. The most extensive wooded areas are found along the Escarpment (see Drawing 5), while some remnant stands (heavily thinned) occur above the Escarpment in various school yards and parks. Drawing 5 also shows that most of the open space within the Corridor is either cleared or sparsely treed. Such areas are referred to as "grasslands".

Initial site visits indicate that the wooded portion of the Escarpment has been removed in the past, and now represents second or perhaps third generation growth, characterized by semi-tolerant and tolerant species of the Great Lakes - St. Lawrence Forest Region (i.e., white oak, beech, sugar maple).



VEGETATION

NOTE: TREES ARE PREDOMINANTLY DECIDUOUS

Legend

ESCARPMENT

FORESTED

DENUDED

OPEN SPACE

TREESCAPED (Indigenous or Landscaped)

GRASSLAND

STREETSCAPES

MATURE TREES–HIGH DENSITY

MATURE TREES–MODERATE DENSITY

MATURE TO IMMATURE TREES–LIGHT DENSITY

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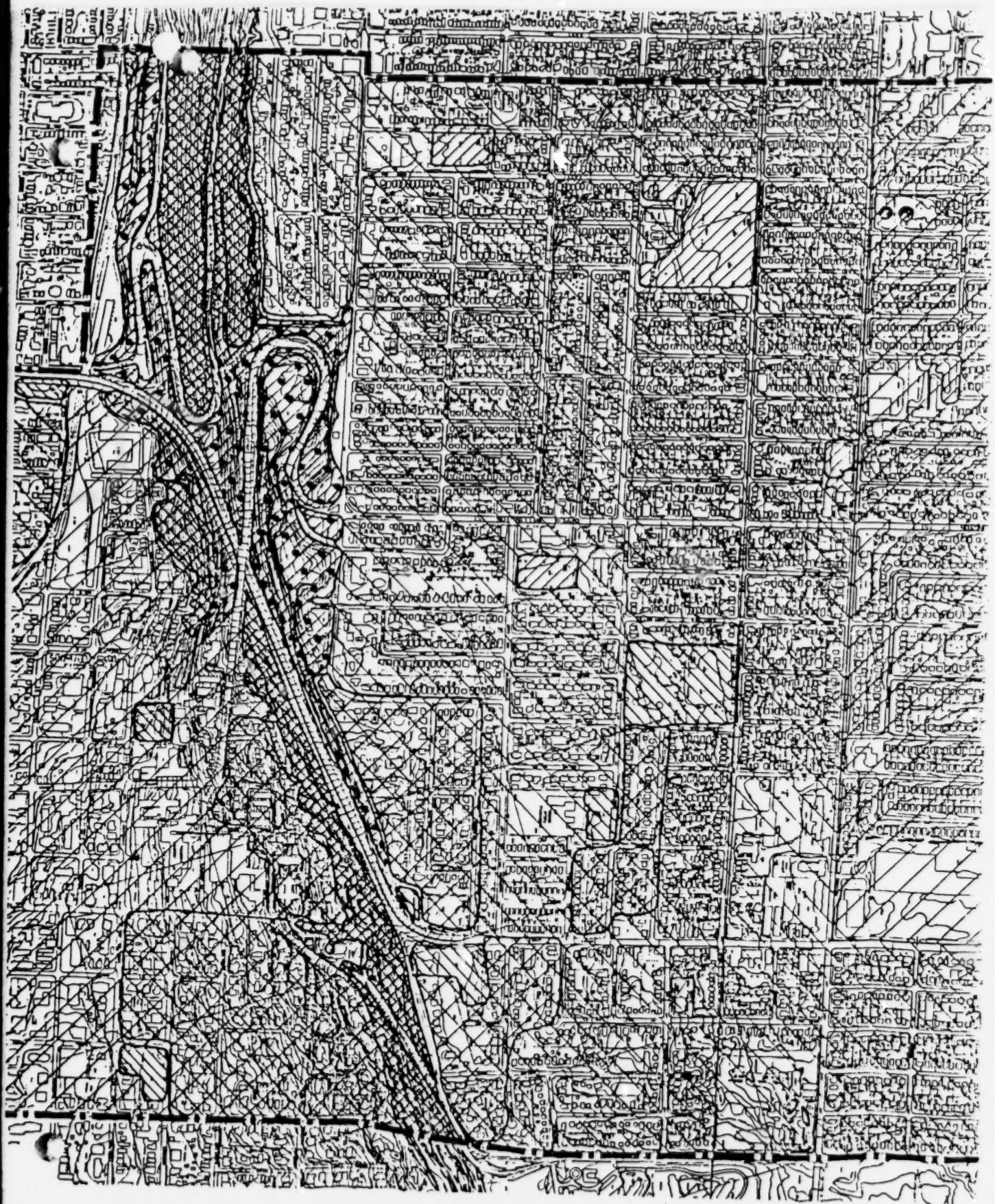
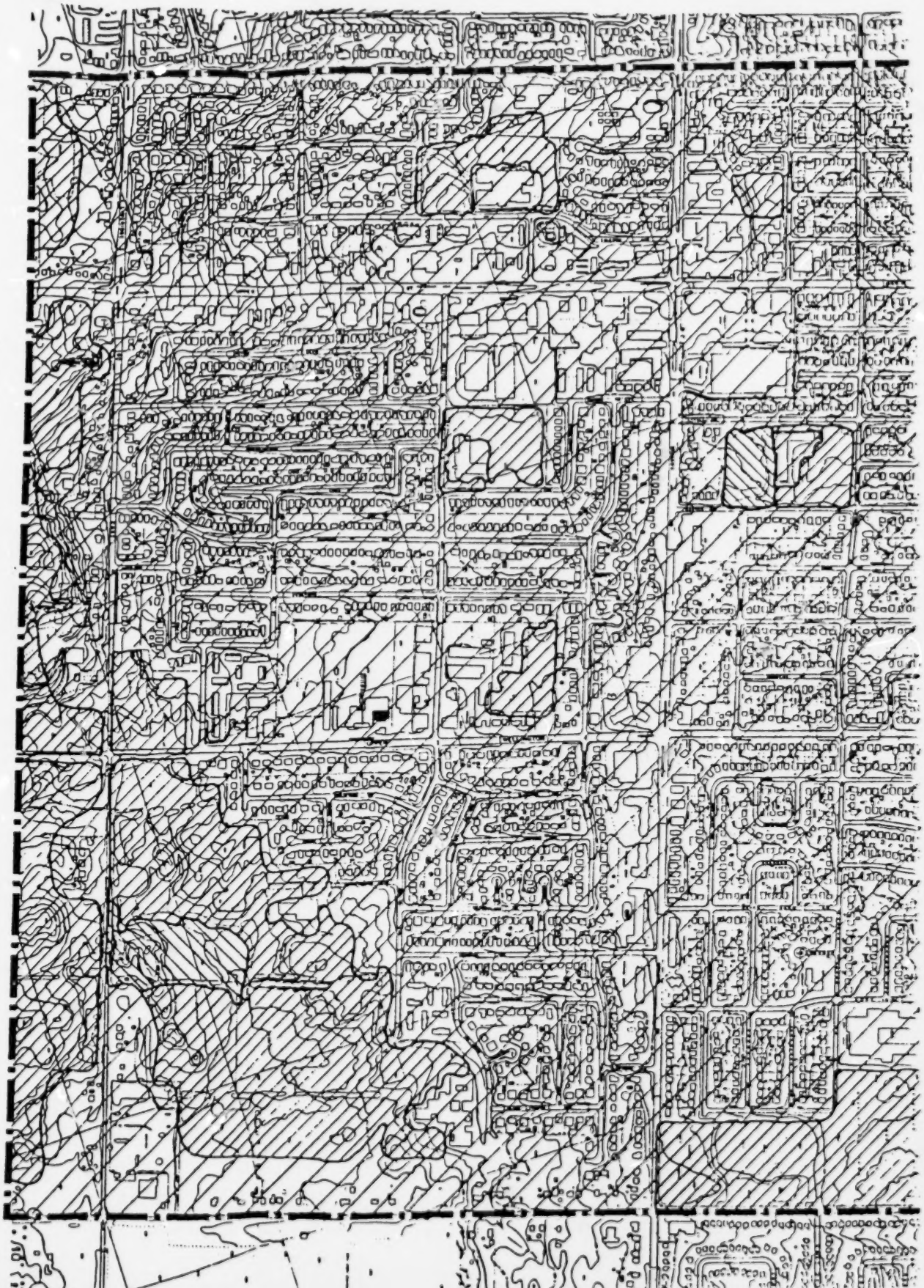
Drawing No.5





Remnant stands on and near the top of the Escarpment, however, contain indigenous species of the Carolinean Region, including shagbark hickory which is the most common representative.

Perhaps the most important role of vegetation in the study area is that it enhances the urban environment. Trees provide shade, ameliorate climatic effects, enhance visual diversity and soften the physical realities of an urban environment. In addition to increasing property values, they often instill an intangible community pride, particularly in local residents.

Aesthetically, wooded areas along the Escarpment serve two basic functions; they provide an attractive backdrop to the downtown area, and they frame vistas and panoramas from the top of the Escarpment. These wooded slopes also provide natural hiking opportunities for local residents and accommodate a segment of the Bruce Trail.

3.7 Terrestrial and Avian Wildlife

With the exception of forested sections of the Escarpment, the Study Corridor is primarily an urban environment. Even those sections above the Escarpment towards the southern boundary of the Study Corridor, which are now in a natural or quasi-natural state, are in the process of being urbanized.

Often, urban settings are considered to be sterile with respect to most wildlife, though this is not always the case. While it is true that urbanization may severely alter the habitat and species composition representative of rural environments, it may also create a new environment, often more diverse than the old. Such diversity is related to the variety of plant material present which in turn attracts a diversity of both terrestial and avian wildlife species. Although some of these wildlife species are considered pests, urban settings often bring people and wildlife together on a more frequent basis than in rural settings.

It should also be noted that urban settings often contain a higher carrying capacity for wildlife than do rural environments owing once again to the high diversity of available food and shelter. Research has shown that 15 to 50 year old subdivisions, similar to those on the upper and lower portions of the Study Corridor, often contained medium to high plant diversity and biomass, capable of medium to high net primary production (Dorney, 1979). Therefore, it is expected that the Study Corridor, which has well treed urban areas and heavily forested sections along the Escarpment, does contain a high diversity of terrestial and avian wildlife. While the existence of wildlife in the Corridor is not adequately documented by existing data, the probability of the existence of wildlife, based on findings in similar settings, warrants some consideration in the alignment selection process. Proposed alignments must therefore be sensitive to possible impacts on the existing vegetation which may provide habitat for wildlife species.

The Study Corridor does not contain any wetlands or water courses considered suitable to support waterfowl or fish habitats.

3.8 Air Quality

The Ministry of the Environment air quality monitoring network in Hamilton is shown in Figure 2. Monitoring is most concentrated in the area below the Niagara Escarpment, and the network is centred on two major stations: 29025 - Barton/Sanford, located halfway between downtown and the heavy industrial area; and 29008 - North Park, located on the Beach Strip adjacent to the Queen Elizabeth Way.

a) Air Pollution Index

The Hamilton Air Pollution Index (API) is used as a warning system to alert the public to elevated air pollutant levels. The index is derived from 24-hour average concentrations of sulphur dioxide and particulate matter as measured at the Barton/Sanford station. When conditions are such that the API reaches 32 and there is also a forecast of unfavourable dispersion conditions

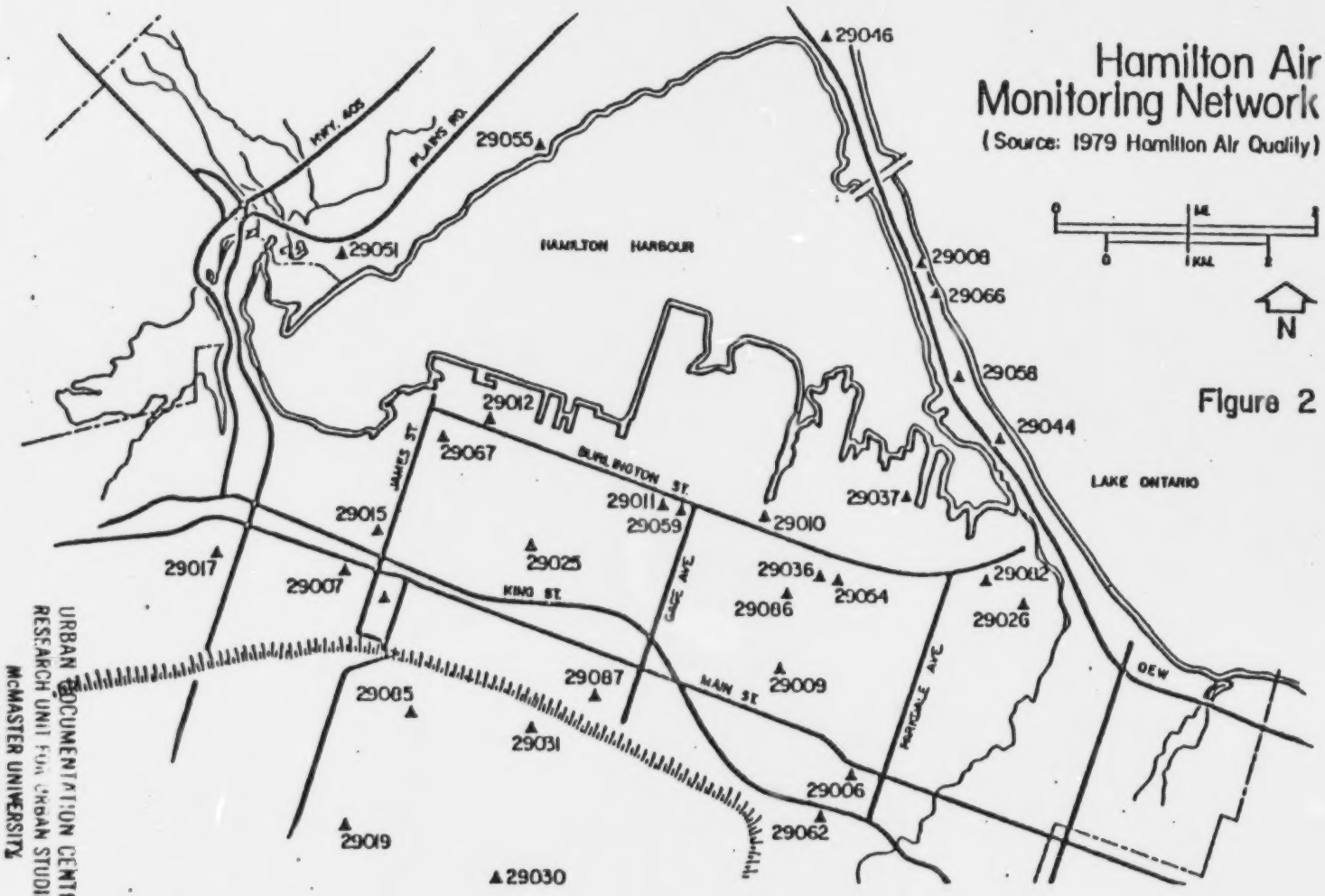


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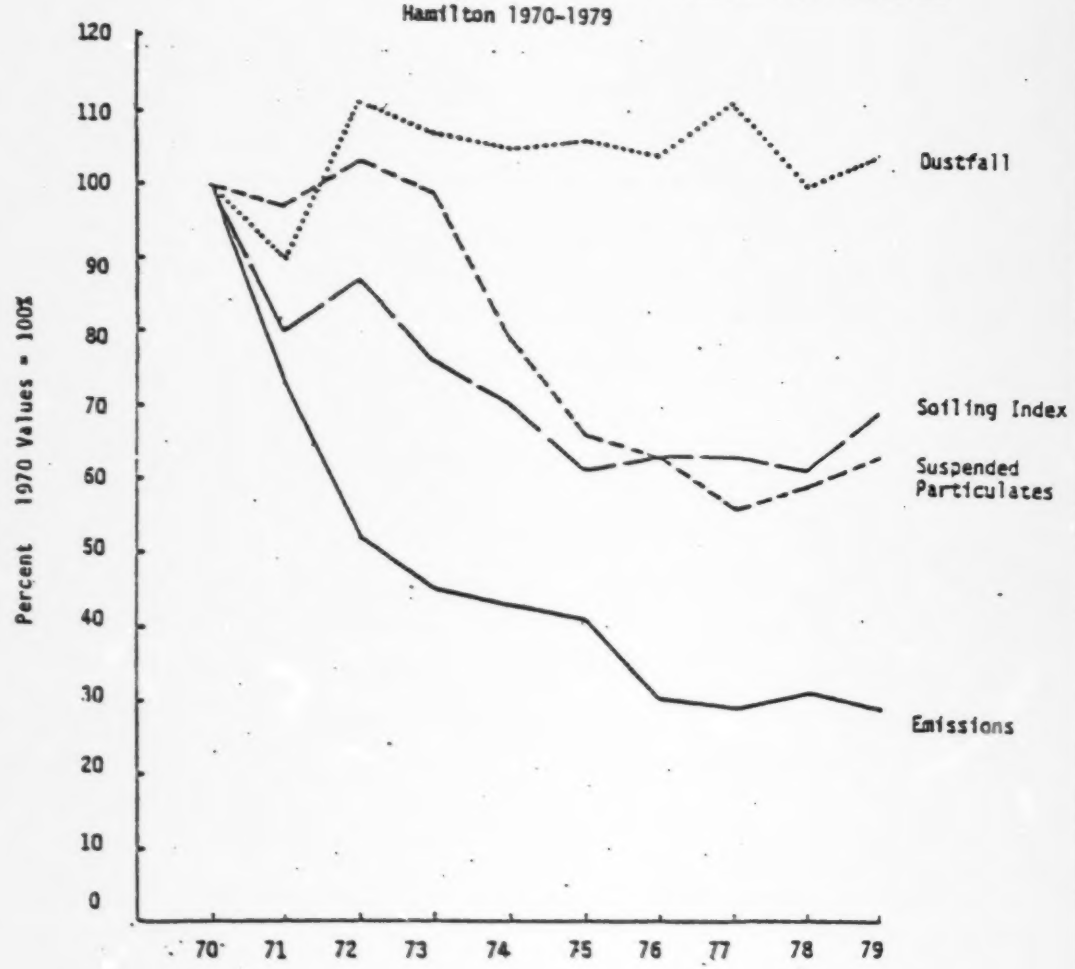
FIGURE 3

Particulate Trends vs Estimated Total Emissions
Hamilton 1970-1979



	70	71	72	73	74	75	76	77	78	79	
Suspended Particulates (7 stations)	131	127	135	130	104	86	83	73	77	82	ug/m^3
Dustfall (17 stations)	9.4	8.5	10.4	10.1	9.9	10.0	9.8	10.4	9.4	9.8	g/sq.m/30 days
Soiling Index (7 stations)	.54	.43	.47	.41	.38	.33	.34	.34	.33	.37	COH's/1000 ft.
Institutional & Industrial Emissions	56	41	29	25	24	23	17	16	17.5	16	10^6 lbs/year

(Source: 1979 Hamilton Air Quality)

(e.g., low wind speed and/or the presence of inversions), major emitters are asked to voluntarily curtail certain operations. When conditions are such that the API reaches 50 these cutbacks become mandatory.

During 1979 there were 22 instances of the API reaching or exceeding 32; and for the first time since 1970, it once exceeded 50. In previous years there were usually fewer than 10 such occurrences, which were generally of less severity and shorter duration. According to the Ministry of the Environment, this reflects a greater frequency of unfavourable dispersion conditions (Ministry of the Environment, 1979). Industrial emissions have remained essentially unchanged since 1976.

b) Particulates

Three methods of measurement used to monitor concentrations of particulates are dustfall, suspended particulates and the soiling index. Dustfall is made up of heavy material generally greater than 10 microns in diameter. Suspended particulates range in size from submicron to 50 microns. The soiling index is a measurement of fine material from submicron to approximately 10 microns in diameter.

Figure 3 indicates that levels of suspended particulates and the soiling index dropped significantly in the early 1970's and have remained relatively stable since 1975. This improvement is attributable to substantial reductions in emissions. Objectives established by the Ministry of the Environment are frequently exceeded in many parts of the City, especially in heavily industrialized areas. In much of the City, dustfall levels are well above the objectives established by the Ministry of the Environment. As Figure 3 indicates, dustfall levels have remained virtually unchanged throughout the 1970's.

c) Sulphur Dioxide

Most sulphur dioxide (SO_2) emissions stem from industrial sources, while a small portion can be attributed to the burning of fuel for domestic purposes. Sulphur dioxide concentrations in Hamilton are monitored continuously at both the Barton/Sanford and North Park stations. Slight decreases in sulphur dioxide levels have been observed in recent years. Yearly means have consistently remained below the objective of 52 $\mu g/m^3$ established by the Ministry of the Environment. Hourly and daily objectives have been exceeded only in isolated incidents.

d) Total Reduced Sulphur

The primary source of emissions of hydrogen sulphide (H_2S) and related sulphur compounds is industrial. Municipal and natural sources are minor contributors. Concentrations of these emissions, which are reported as total reduced sulphur, are monitored continuously at the Barton/Sanford and North Park stations. Annual average hourly values have remained well below the targeted 28 $\mu g/m^3$ established by the Ministry of the Environment, although the hourly limit has occasionally been exceeded. In 1979, the hourly limit was exceeded on 75 occasions at Barton/Sanford and on 3 occasions at North Park. The high concentrations at Barton/Sanford often occurred during inversions, whereas at North Park southwesterly winds normally offer good dispersion of emissions.

e) Carbon Monoxide

The automobile is the major source of carbon monoxide (CO) emissions with minor contributions from industry. Carbon monoxide levels are monitored at the Barton/Sanford station. A marked reduction in carbon monoxide levels occurred between 1970 and 1975. Since 1975, carbon monoxide levels have remained relatively stable, well below the objectives established by the Ministry of the Environment.

f) Oxides of Nitrogen

The primary sources of oxides of nitrogen are high temperature combustion sources (e.g., industry and automobiles). Nitric oxide (NO), nitrogen dioxide (NO_2) and total nitrogen oxides are monitored continuously at the Barton/Sanford and North Park stations. The Ministry of the Environment has established objectives only for nitrogen dioxide. During the period from 1975 to 1979 annual average hourly levels of nitrogen dioxide remained well below the established objectives. An unexplained peaking of nitrogen dioxide concentrations, common to other locations in the province, was observed in 1977 (Ministry of the Environment, 1979). Concentrations of nitric oxide remained stable over this period. Although nitrogen dioxide levels were similar at each station, nitric oxide levels at North Park were approximately 2½ times as high as those monitored at Barton/Sanford. These findings may be the result of the close proximity of North Park to the Queen Elizabeth Way (Ministry of the Environment, 1979). Most vehicular emissions of oxides of nitrogen consist of nitric oxide which is subsequently oxidized to nitrogen dioxide in the atmosphere. At North Park, nitric oxide concentrations are probably monitored before this oxidation can take place.

g) Ozone

Ozone (O_3) is a product of photochemical reactions involving nitrogen oxides, hydrocarbons, and sunlight. Ozone concentrations are directly related both to the amount and intensity of sunlight. Daily maximum concentrations occur during midafternoon, and annual maximum concentrations occur from May through September. The one hour objective of 157 $\mu g/m^3$ established by the Ministry of the Environment is occasionally exceeded. Such exceedences are widespread throughout the region and are usually considered to be a result of long range transport from the United States. Ozone concentrations in Hamilton are among the lowest recorded in Southern Ontario, probably due to the numerous high temperature combustion sources which produce

3.9 Climatic Factors

Hamilton is located in the semi-continental climatic zone which is characterized by cold winters, hot summers, and precipitation throughout the year. The two features which exert the most significant influence on the City's climate are Lake Ontario and the Niagara Escarpment. Generally, the climate of the upper plateau tends to be cooler and less humid than the climate of the lower plateau.

a) Temperature

Normal values of temperature based on the current standard 30 year period (1941 to 1970) are available for four stations in Hamilton, two above and two below the Niagara Escarpment (Environment Canada). According to these values the mean daily annual temperature is between 7.7°C and 9.1°C. Lowest mean daily temperatures occur in January and vary from -5.9°C to -3.9°C. Highest mean daily temperatures occur in July and vary from 20.6°C to 22.4°C. Temperatures drop below freezing on 132 to 152 days per year. The first frost occurs in October, the last in May, with approximately all below freezing temperatures occurring between November and March. Mean daily, monthly and annual temperatures at each of the four stations for the period from 1941 to 1970 are listed in Tables 1 (a) and (b).

b) Precipitation

Precipitation normals, based on the period 1941 to 1970, are available for the same locations as temperature normals (Environment Canada). Average annual rainfall varies from 66.8 to 71.1 centimetres and average annual snowfall varies from 113.5 to 131.3 centimetres. Using a conversion factor of 0.1 to produce a numerical equivalent of snowfall as liquid precipitation, the average annual total precipitation varies from 79.2 to 84.3 centimetres. Snowfall usually occurs from October

ELEMENT and STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
616 HAMILTON	LATITUDE 43 16 N LONGITUDE 79 56 W ELEVATION 303 FT ASL												
MEAN DAILY TEMPERATURE (DEG F)	24.9	25.6	33.4	45.4	55.6	67.1	72.4	70.6	62.1	52.3	40.2	29.5	48.3
MEAN DAILY MAXIMUM TEMPERATURE	32.1	33.1	41.0	54.5	65.7	77.6	82.7	80.9	72.3	61.6	46.9	36.0	57.0
MEAN DAILY MINIMUM TEMPERATURE	17.6	18.0	25.7	36.2	45.5	56.6	62.0	60.3	51.9	43.0	33.4	23.0	39.4
EXTREME MAXIMUM TEMPERATURE	65	63	81	88	93	102	106	102	100	90	78	62	106
NO. OF YEARS OF RECORD	64	65	66	63	63	63	60	54	60	62	65	64	
EXTREME MINIMUM TEMPERATURE	-23	-21	-19	6	19	30	34	35	25	12	- 9	-18	-23
NO. OF YEARS OF RECORD	65	65	64	64	63	64	60	53	60	62	64	65	
NO. OF DAYS WITH FROST	29	27	25	9	1	0	0	0	*	2	14	26	133
MEAN RAINFALL (INCHES)	1.15	1.40	1.90	2.61	3.09	2.37	2.97	2.95	2.47	2.50	2.21	1.23	26.85
MEAN SNOWFALL	10.7	9.8	8.8	1.2	0.0	0.0	0.0	0.0	0.0	0.4	2.8	11.0	44.7
MEAN TOTAL PRECIPITATION	2.23	2.38	2.78	2.72	3.09	2.37	2.97	2.95	2.47	2.54	2.39	2.33	31.22
GREATEST RAINFALL IN 24 HRS	4.59	1.91	1.90	2.20	3.18	3.50	2.12	3.04	3.69	3.65	2.23	1.90	4.59
NO. OF YEARS OF RECORD	45	45	48	53	59	59	61	50	59	58	59	47	
GREATEST SNOWFALL IN 24 HRS	20.0	12.0	20.0	14.0	3.0	0.0	0.0	0.0	0.0	3.0	11.0	11.0	20.0
NO. OF YEARS OF RECORD	53	54	51	63	68	65	64	62	65	65	64	55	
GREATEST PRECIPITATION IN 24 HRS	4.59	1.91	3.27	2.20	3.18	3.50	2.12	3.04	3.69	3.65	2.28	1.90	4.59
NO. OF YEARS OF RECORD	42	42	43	53	59	59	61	50	59	58	59	45	
NO. OF DAYS WITH MEASURABLE RAIN	4	3	3	8	9	8	8	7	7	7	8	5	81
NO. OF DAYS WITH MEASURABLE SNOW	6	5	3	1	0	0	0	0	0	*	2	4	21
NO. OF DAYS WITH M. PRECIPITATION	8	8	9	8	9	8	8	7	7	7	9	9	93
620 HAMILTON A	LATITUDE 43 10 N LONGITUDE 79 56 W ELEVATION 808 FT ASL												
MEAN DAILY TEMPERATURE (DEG F)	21.3	22.6	31.3	44.4	54.6	64.6	69.0	67.6	60.7	50.2	38.3	26.3	45.9
MEAN DAILY MAXIMUM TEMPERATURE	28.5	30.8	39.8	54.4	65.3	75.3	79.7	78.8	71.0	60.0	45.7	33.5	55.2
MEAN DAILY MINIMUM TEMPERATURE	14.1	14.4	23.6	34.3	43.9	53.8	58.2	56.3	50.4	40.3	30.8	19.0	36.6
EXTREME MAXIMUM TEMPERATURE	56	53	70	85	91	93	94	92	90	82	76	62	94
NO. OF YEARS OF RECORD	10	10	11	11	11	9	11	9	10	11	12	12	
EXTREME MINIMUM TEMPERATURE	-15	-11	- 5	14	25	36	42	34	31	18	9	-14	-15
NO. OF YEARS OF RECORD	9	10	10	11	11	10	11	10	11	11	12	12	
NO. OF DAYS WITH FROST	30	27	27	14	3	0	0	0	*	5	16	28	150
MEAN RAINFALL (INCHES)	1.09	1.07	1.56	3.02	2.53	2.24	2.83	2.80	2.89	2.65	2.35	1.29	26.32
MEAN SNOWFALL	15.8	10.2	6.5	1.9	1	0.0	0.0	0.0	0.0	0.1	5.0	10.7	50.2
MEAN TOTAL PRECIPITATION	2.67	2.09	2.21	3.21	2.53	2.24	2.83	2.80	2.89	2.66	2.85	2.36	31.34
GREATEST RAINFALL IN 24 HRS	1.10	0.98	0.94	1.90	1.57	2.14	2.05	1.95	1.45	1.58	2.11	1.39	2.14
NO. OF YEARS OF RECORD	5	7	8	9	11	9	11	10	11	10	11	12	
GREATEST SNOWFALL IN 24 HRS	17.0	10.0	8.0	4.0	0.0	0.0	0.0	0.0	0.0	9.3	5.0	14.0	17.0
NO. OF YEARS OF RECORD	7	9	7	9	10	10	11	10	11	11	10	9	
GREATEST PRECIPITATION IN 24 HRS	1.70	1.00	0.94	1.50	1.57	2.14	2.05	1.95	1.45	1.58	2.11	1.40	2.14
NO. OF YEARS OF RECORD	6	7	7	9	11	9	11	10	11	10	11	11	
NO. OF DAYS WITH MEASURABLE RAIN	3	1	5	10	10	8	7	7	8	8	10	5	82
NO. OF DAYS WITH MEASURABLE SNOW	6	5	5	2	0	0	0	0	0	*	2	6	26
NO. OF DAYS WITH M. PRECIPITATION	10	6	9	11	10	8	7	7	8	8	12	12	108
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR

Table 1 (a): Temperature and Precipitation Normals
(Source: Temperature and Precipitation - 1941-1970 - Ontario)

ELEMENT and STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
888 HAMILTON ONT HOSPITAL	LATITUDE 43 14 N				LONGITUDE 79 54 W			ELEVATION		650 FT ASL			
MEAN DAILY TEMPERATURE (DEG F)	22.8	23.5	31.6	44.3	54.8	65.9	70.5	69.0	62.3	51.8	40.3	27.3	46.9
MEAN DAILY MAXIMUM TEMPERATURE	27.9	30.2	38.3	52.7	64.0	75.5	79.8	78.1	70.4	59.9	46.0	33.0	54.3
MEAN DAILY MINIMUM TEMPERATURE	16.8	16.7	24.9	35.8	45.5	56.2	61.1	59.8	53.9	43.7	34.5	21.5	39.1
EXTREME MAXIMUM TEMPERATURE	57	54	72	86	93	94	96	95	90	83	78	63	96
NO. OF YEARS OF RECORD	9	9	11	11	11	11	11	11	11	10	11	11	
EXTREME MINIMUM TEMPERATURE	-10	-11	- 6	16	28	39	45	40	35	21	15	- 8	-11
NO. OF YEARS OF RECORD	9	9	11	11	11	11	11	11	11	10	11	11	
NO. OF DAYS WITH FROST	29	27	25	9	1	0	0	0	0	3	12	26	132
MEAN RAINFALL (INCHES)	1.25	1.12	1.61	2.89	2.85	2.79	2.98	3.20	2.72	2.72	2.38	1.28	27.79
MEAN SNOWFALL	13.3	12.6	9.8	0.9	0.0	0.0	0.0	0.0	0.0	1.0	3.1	12.2	51.7
MEAN TOTAL PRECIPITATION	2.58	2.32	2.51	3.02	2.85	2.79	2.98	3.20	2.72	2.82	2.71	2.50	33.20
GREATEST RAINFALL IN 24 HRS	1.42	1.22	1.05	1.24	1.80	2.53	3.31	2.46	2.82	1.65	1.80	1.46	3.31
NO. OF YEARS OF RECORD	7	8	9	9	11	11	11	11	11	11	10	7	
GREATEST SNOWFALL IN 24 HRS	10.0	6.0	6.7	5.1	0.0	0.0	0.0	0.0	0.0	9.7	3.3	9.8	10.0
NO. OF YEARS OF RECORD	7	8	9	9	11	11	11	11	11	11	9	7	
GREATEST PRECIPITATION IN 24 HRS	2.22	1.22	1.05	1.24	1.80	2.53	3.31	2.46	2.82	1.65	1.80	1.46	3.31
NO. OF YEARS OF RECORD	9	9	10	10	11	11	11	11	11	11	10	9	
NO. OF DAYS WITH MEASURABLE RAIN	4	3	6	11	10	9	9	8	8	9	11	6	94
NO. OF DAYS WITH MEASURABLE SNOW	5	6	3	1	0	0	0	0	0	*	1	6	22
NO. OF DAYS WITH M. PRECIPITATION	10	8	9	11	10	9	9	8	8	9	13	13	117
888 HAMILTON RBG	LATITUDE 43 17 N				LONGITUDE 79 53 W			ELEVATION		335 FT ASL			
MEAN DAILY TEMPERATURE (DEG F)	23.5	25.0	32.7	44.9	55.1	65.8	70.8	69.2	62.1	51.8	40.2	28.6	47.5
MEAN DAILY MAXIMUM TEMPERATURE	30.3	32.5	40.1	54.2	65.3	76.0	80.9	79.1	71.3	60.9	47.1	34.8	56.1
MEAN DAILY MINIMUM TEMPERATURE	16.6	17.5	25.3	35.5	44.9	55.5	60.6	59.3	52.5	42.6	33.2	22.3	38.8
EXTREME MAXIMUM TEMPERATURE	58	62	72	87	95	95	100	100	100	90	79	66	100
NO. OF YEARS OF RECORD	20	20	20	21	21	21	21	21	21	21	21	21	
EXTREME MINIMUM TEMPERATURE	-13	-14	- 3	12	29	36	45	40	32	21	6	-12	-14
NO. OF YEARS OF RECORD	20	20	20	21	21	21	21	21	21	21	21	21	
NO. OF DAYS WITH FROST	29	26	25	10	1	0	0	0	*	3	14	26	134
MEAN RAINFALL (INCHES)	1.18	1.23	1.84	2.90	2.82	2.78	2.82	3.04	2.80	2.66	2.29	1.60	27.96
MEAN SNOWFALL	14.4	11.4	7.5	1.7	1	0.0	0.0	0.0	0.0	0.6	3.6	10.3	49.5
MEAN TOTAL PRECIPITATION	2.60	2.37	2.58	3.07	2.82	2.78	2.82	3.04	2.80	2.72	2.64	2.63	32.87
GREATEST RAINFALL IN 24 HRS	1.33	1.87	1.54	1.72	3.18	2.25	2.26	3.09	2.09	3.87	2.74	1.39	3.87
NO. OF YEARS OF RECORD	20	20	20	21	21	21	21	21	21	21	21	21	
GREATEST SNOWFALL IN 24 HRS	15.1	10.0	7.3	4.9	0.4	0.0	0.0	0.0	0.0	5.9	10.0	7.9	15.1
NO. OF YEARS OF RECORD	20	20	20	21	21	21	21	21	21	21	21	21	
GREATEST PRECIPITATION IN 24 HRS	1.51	1.54	1.69	1.72	3.18	2.25	2.26	3.09	2.09	3.87	2.74	1.51	3.87
NO. OF YEARS OF RECORD	20	20	20	21	21	21	21	21	21	21	21	21	
NO. OF DAYS WITH MEASURABLE RAIN	5	4	7	11	10	9	8	9	8	9	9	6	95
NO. OF DAYS WITH MEASURABLE SNOW	10	8	6	2	*	0	0	0	0	*	3	9	38
NO. OF DAYS WITH M. PRECIPITATION	13	11	12	11	10	9	8	9	8	9	12	13	125
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR

Table 1 (b): Temperature and Precipitation Normals

(Source: Temperature and Precipitation - 1941-1970 - Ontario)

through April, with approximately 90% of snowfall occurring from December through March. Rainfall occurs throughout the entire year with two peak periods. The first peak, which occurs in April and May accounts for approximately 21% of annual rainfall; the second peak, from July through September, accounts for 32% of annual rainfall. Measurable precipitation occurs on 97 to 128 days per year. Monthly and annual precipitation normals at each of the four stations for the period from 1941 to 1970 are listed in Tables 1(a) and (b).

c) Sunshine

Normal values of daily bright sunshine based on the period 1941 to 1970 are available for the station located in Hamilton's Royal Botanical Gardens (Yorke, B.J.). These values indicate that bright sunshine occurs for an average of 2035 hours per year, approximately 52% of it occurring between May and August for an average of 8½ hours per day. Table 2 lists average monthly and annual hours of bright sunshine at the station during the study period.

d) Wind

Wind normals based on the period 1955 to 1972 are available for two stations in Hamilton, one located in the Royal Botanical Gardens and the other on the Marine Police docks at the western end of Hamilton Harbour (Environment Canada). Prevailing winds are westerly at the Marine Police station and southwesterly at the Royal Botanical Gardens station. Average wind speeds vary with location and time of year, tending to be slightly greater where the prevailing winds are westerly and during winter and early spring. At the Marine Police station, wind speeds average 15.0 to 16.7 km/h (9.3 to 10.4 mph) from November through May, and 12.6 to 13.7 km/h (7.8 to 8.5 mph) from June through October. At the Royal Botanical Gardens station, wind speeds average 13.7 to 14.8 km/h (8.5 to 9.2 mph) from November through May and 10.3 to 11.3 km/h (6.4 to 7.0 mph) from June through October. Maximum observed wind speeds vary from 66 to 76 km/h (41 to 47 mph), with

Table 2

Average Monthly and Yearly Hours of Bright Sunshine

Royal Botanical Gardens, Hamilton

(Source: Environment Canada Amospheric Environment Service

Daily Bright Sunshine 1941-1970)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
93	120	140	171	245	261	281	263	171	142	74	74	2035

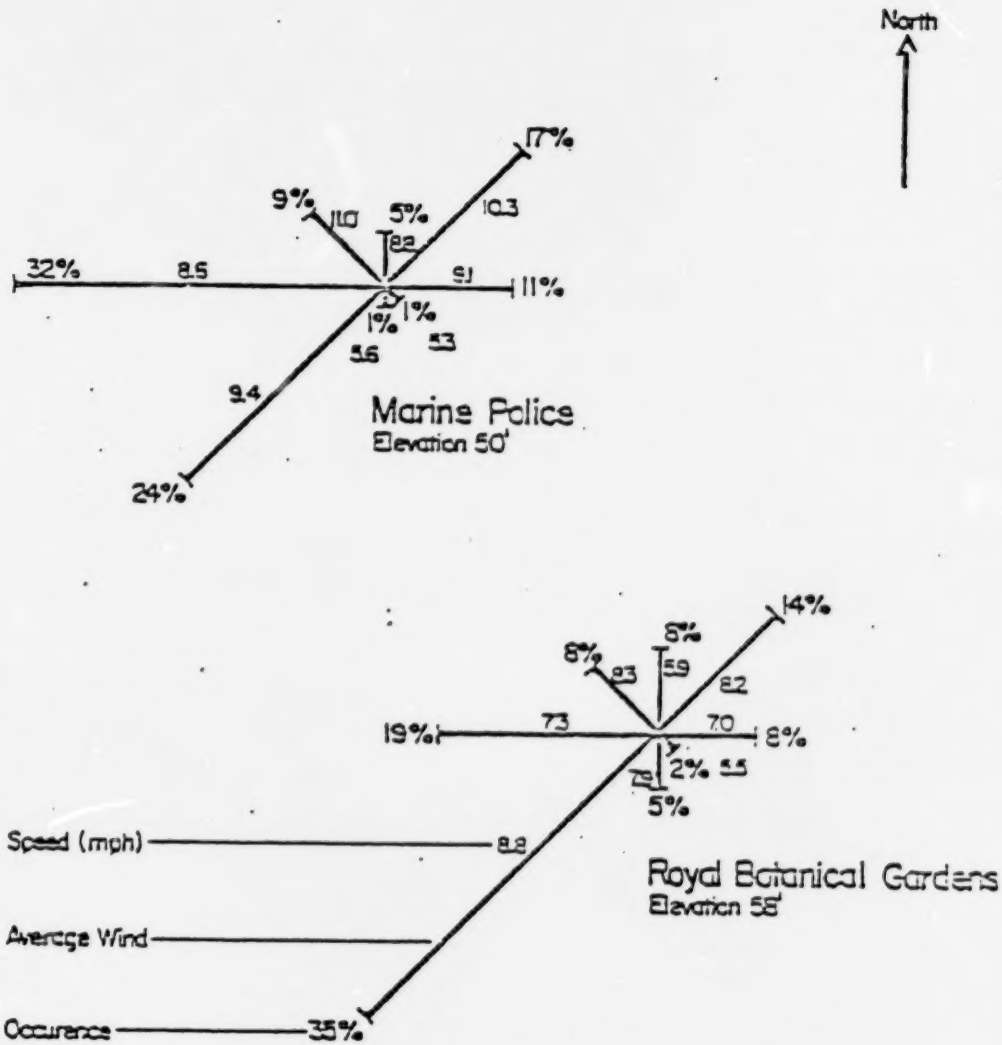


Figure 4

Annual Wind Roses in Hamilton

(Adapted from: Canadian Normals Vol. 3 -Wind)

e) Inversions

In Hamilton, advection inversions, frontal inversions and subsidence inversions are of importance (Ministry of Environment). Inversions occur most frequently in spring and late summer. Advection inversions often occur in conjunction with frontal or subsidence inversions.

Advection inversions occur when cool air from over Lake Ontario flows into the City. This layer of cooler and denser air is usually high enough to extend above the escarpment. Warmer and less dense air coming from the south flows over the cool air forming the inversion interface. Figure 5 illustrates an advection inversion.

Frontal inversions occur along the boundary of warm and cold air masses. In the case of a warm frontal inversion, a warm air mass overtakes and over-rides a cold air mass forming a gently sloped inversion layer that may extend for hundreds of kilometres. Because the winds generally associated with warm fronts in Hamilton blow from the east across the lake, warm frontal inversions are often accented by advection inversions.

Subsidence inversions are caused by the slow descent of air from higher elevations in the center of high pressure systems. This causes the air in an elevated layer to be compressed, thereby raising its temperature and creating an inversion layer. These inversions are most often formed in slow moving or stationary high pressure cells.

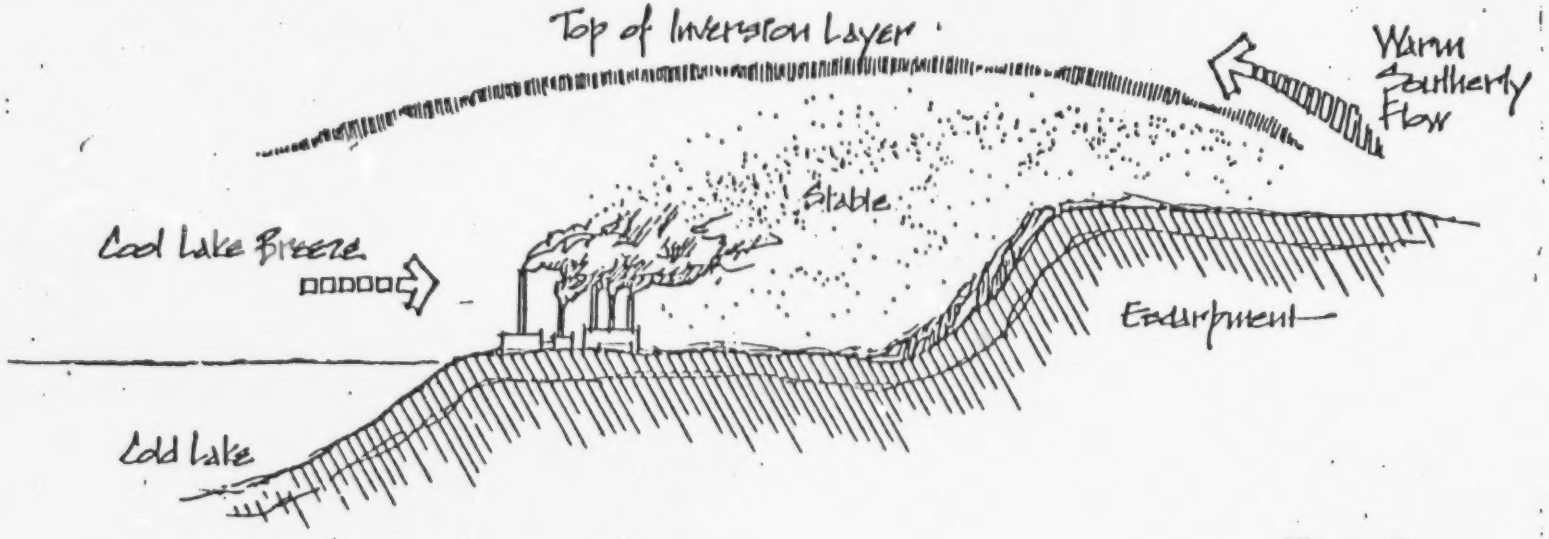


Figure 5

Lake Induced Advection Inversion

(Source: 1979 Hamilton Air Quality)

3.10 Summary of Sensitive/Significant Areas

The following summarizes the sensitive and/or significant aspects of each component of the natural environment previously described. This summary denotes area resources considered worthy of protection and hence identifies potential constraints to be examined as alternative alignments are evaluated.

1)	Geology	- existence of the Irondequoit formation with the Escarpment. A one (1) metre thick stratum, it has been identified by the Niagara Escarpment Commission as a significant geological feature.
2)	Physiography & Soils	- no apparent significant/sensitive physiographic or soils-related feature above or below the Escarpment was identified. The Escarpment and associated talus are unique to the study area and the region. High erosion potential exists along the Escarpment.
3)	Hydrology	- No hazard lands as defined by the Hamilton Region Conservation Authority have been defined. The anticipated occurrence of shallow water bearing zones may be significant to site specific construction activities and concerns for water quality.

4) Water Quality - There are no natural watercourses within or adjacent to the study corridor. The impact of the undertaking on groundwater quality must be examined further.

5) Vegetation - No areas of significant/sensitive vegetation have been identified by the Ministry of Natural Resources or the Niagara Escarpment Commission. Forested areas along the escarpment and residential areas (including parks) with dense to moderately dense tree cover are considered locally significant with respect to visual relief, wildlife, recreation and land values. Future input from environmental interest groups may reveal further significant flora.

6) Wildlife - No area of significant sensitive habitat or the occurrence of unique species have been identified by Ministry of Natural Resources on the Niagara Escarpment Commission. Future input from environmental interest groups may reveal significant sensitive fauna.

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